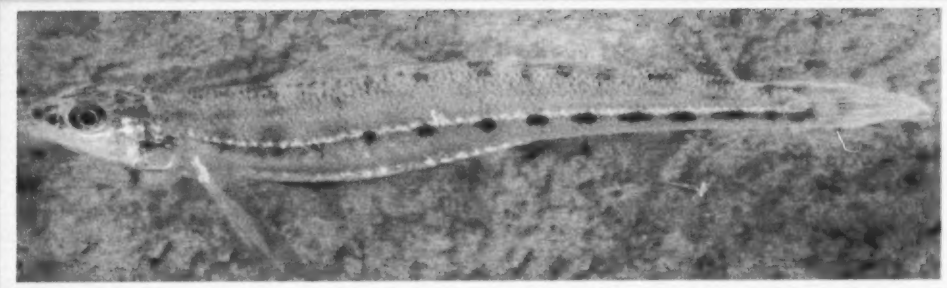
Species at Risk Act
Recovery Strategy Report Series

Report on the Progress of Recovery Strategy Implementation for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada (Ontario Populations) for the Period 2012 - 2017

Eastern Sand Darter



2018

Canada

Recommended Citation:

Fisheries and Oceans Canada. 2018. Report on the Progress of Recovery Strategy Implementation for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada (Ontario Populations) for the Period 2012 – 2017. *Species at Risk Act* Recovery Strategy Report Series. Fisheries and Oceans Canada, Ottawa. v + 33 p.

For copies of the progress report, or for additional information on species at risk, including COSEWIC Status Reports, recovery strategies, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry.

Cover illustration: Alan Dextrase, Ontario Ministry of Natural Resources and Forestry

Également disponible en français sous le titre
« Rapport sur les progrès de la mise en œuvre du programme de rétablissement du dard de sable (*Ammocrypta pellucida*) au Canada, populations de l'Ontario pour la période 2012-2017»

© Her Majesty the Queen in Right of Canada, represented by the Minister of Fisheries and Oceans Canada, 2018. All rights reserved.

ISBN 978-0-660-24756-4

Catalogue no. En3-4/122-1-2018E-PDF

Content (excluding the cover illustration) may be used without permission, with appropriate credit to the source.

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under Section 46 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent ministers are responsible for reporting on the implementation of the recovery strategy for a species at risk, and on the progress towards meeting its objectives within five years of the date when the recovery strategy was placed on the Species at Risk Public Registry and in every subsequent five-year period, until its objectives have been achieved or the species' recovery is no longer feasible.

Reporting on the progress of recovery strategy implementation requires reporting on the collective efforts of the competent minister(s), provincial and territorial governments and all other parties involved in conducting activities that contribute to the species' recovery. Recovery strategies identify broad strategies and approaches that will provide the best chance of recovering species at risk. Some of the identified strategies and approaches are sequential to the progress or completion of others and not all may be undertaken or show significant progress during the time frame of a Report on the Progress of Recovery Strategy Implementation (Progress Report).

The Minister of Fisheries and Oceans is the competent minister(s) under SARA for the Eastern Sand Darter and has prepared this Progress Report.

As stated in the preamble to SARA, success in the recovery of species at risk depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in the recovery strategy and will not be achieved by Fisheries and Oceans Canada, or any other jurisdiction alone. The cost of conserving species at risk is shared among multiple constituencies. All Canadians are invited to join in supporting and implementing the Recovery Strategy for the Eastern Sand Darter for the benefit of the species and Canadian society as a whole.

Acknowledgments

This Progress Report was prepared by Josh Stacey (DFO) and Amy Boyko (DFO). To the extent possible, this Progress Report has been prepared with inputs from the Ontario Ministry of Natural Resources and Forestry and Environment and Climate Change Canada. The Department of Fisheries and Oceans would also like to express its appreciations to all individuals and organizations who have contributed to the recovery of the Eastern Sand Darter.

Executive Summary

The Eastern Sand Darter was listed as Threatened under the *Species at Risk Act* in 2003. In 2009, the Committee on the Status of Endangered Wildlife in Canada split the species into two designable units, consisting of Quebec and Ontario populations. The *Recovery Strategy for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada: Ontario Populations* was finalized and published on the Species at Risk Public Registry in 2012.

The main threats identified for Eastern Sand Darter (Ontario Populations) (hereafter referred to as Eastern Sand Darter) include: sediment loading, nutrient loading, pollution resulting from agricultural and urban development, barriers to movement, and alterations in flow regimes and hydrological coastal processes. Invasive species, such as the Round Goby and Common Reed, may also be negatively impacting Eastern Sand Darter.

The population and distribution objective for Eastern Sand Darter is to ensure the survival of self-sustaining population(s) at the six extant locations (Sydenham River, Thames River, Lake St. Clair, Big Creek, Grand River, Lake Erie [Long Point Bay]) and restore self-sustaining population(s) at the following locations: Ausable River, Lake Erie (Rondeau Bay and Pelee Island), Catfish Creek, and Big Otter Creek, where feasible.

Since the publication of the Recovery Strategy in 2012, two major detections of Eastern Sand Darter have been made that are significant to the recovery of the species in Ontario, specifically the Detroit River as well as West Lake (Prince Edward County), which represents the first detection of Eastern Sand Darter within the Lake Ontario watershed. Outreach activities conducted by Fisheries and Oceans Canada and the Ontario Ministry of Natural Resources and Forestry directly or through the Habitat Stewardship Program and Species at Risk Stewardship Fund, respectively, have generated awareness of Eastern Sand Darter, the species' critical habitat and the threats that jeopardize that habitat. These activities have included media broadcasts, presentations, and stewardship training. Similarly, habitat improvement and restoration activities such as vegetation planting, riparian stabilization and the removal of invasive vegetation have been conducted within watersheds occupied by Eastern Sand Darter. Taken together, these activities represent progress towards implementing species recovery actions.

Table of Contents

Preface ii
Acknowledgments ii
Executive Summary iii
1 Introduction 1
2 Background 1
2.1 COSEWIC Assessment Summary 1
2.2 Distribution 2
2.3 Threats 5
2.3.1 Threats to Critical Habitat 7
2.4 Recovery 10
2.4.1 Recovery Goal and Population and Distribution Objectives 10
2.4.2 Performance Indicators 11
3 Progress Towards Recovery 12
3.1 Activities Supporting Recovery 12
3.2 Activities Supporting the Identification of Critical Habitat 25
3.3 Summary of Progress Towards Recovery 27
3.3.1 Status of Performance Indicators 27
3.3.2 Completion of Action Plan 30
3.3.3 Critical Habitat Identification and Protection 30
3.3.4 Recovery Feasibility 30
4 Concluding Statement 30
5 References 32

1 Introduction

This Progress Report outlines the progress towards meeting the objectives listed in the *Recovery Strategy for the Eastern Sand Darter (*Ammocrypta pellucida*) (Ontario Populations)* (hereafter referred to as Eastern Sand Darter) from 2012[1] to 2017 and should be considered as one in a series of documents for this species that are linked and should be considered together; including, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Report (COSEWIC 2009), the Recovery Potential Assessment (Fisheries and Oceans Canada [DFO] 2011), and the Recovery Strategy (DFO 2012).

Section 2 of the progress report reproduces or summarizes key information on the threats to the species, population and distribution objectives for achieving its recovery, approaches to meeting the objectives, and performance indicators to measure the progress of recovery. For more details, readers should refer back to the *Recovery Strategy for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada: Ontario Populations* (DFO 2012). Section 3 reports the progress of activities identified in the Recovery Strategy that support achieving the population and distribution objectives. Section 4 summarizes the progress made and the outcome of the recovery effort.

2 Background

2.1 COSEWIC Assessment Summary

The listing of Eastern Sand Darter in 2003, which led to the Recovery Strategy in 2012, was based on the information provided in the COSEWIC Status Report (COSEWIC 2000). In 2009, COSEWIC reassessed the species' status and confirmed it as Threatened (COSEWIC 2009); however, Canadian Eastern Sand Darter populations were split into two designatable units (DUs), one for Ontario populations and one for Quebec populations. This information has also been included in Section 1.1 of the Recovery Strategy.

Common Name: Eastern Sand Darter – Ontario Populations
Scientific Name: *Ammocrypta pellucida* (Girard 1856)
Status: Threatened
Reason for Designation: This species prefers sand bottom areas of lakes and streams in which it burrows. There is continuing decline in the already small and fragmented populations; four (of 11) have probably been extirpated. The extent of occurrence of this species in Ontario is approximately half of what it was in the 1970s as a result of habitat loss and degradation from increasing urban and agricultural development, stream channelization and competition with invasive alien species.
Occurrence: Ontario
Status History: The species was considered a single unit and designated Threatened in April 1994 and November 2000. When the species was split into separate units in November 2009, the "Ontario populations" unit was designated Threatened.

[1] This document primarily represents the 2012-2017 time period; however, any related progress that occurred in 2010-2012 (the time period when this document was waiting to be posted) will also be reported.

2.2 Distribution

Since 2010, Eastern Sand Darter has been detected in two new locations, the Detroit River and West Lake (Prince Edward County) (Figures 1 and 2). Additionally, the species has been detected at multiple locations throughout its current distribution since the publication of the Recovery Strategy (e.g., Grand, Sydenham and Thames rivers, Lake St. Clair). For further information on targeted and non-targeted surveys for Eastern Sand Darter as of 2010, refer to Table 4.

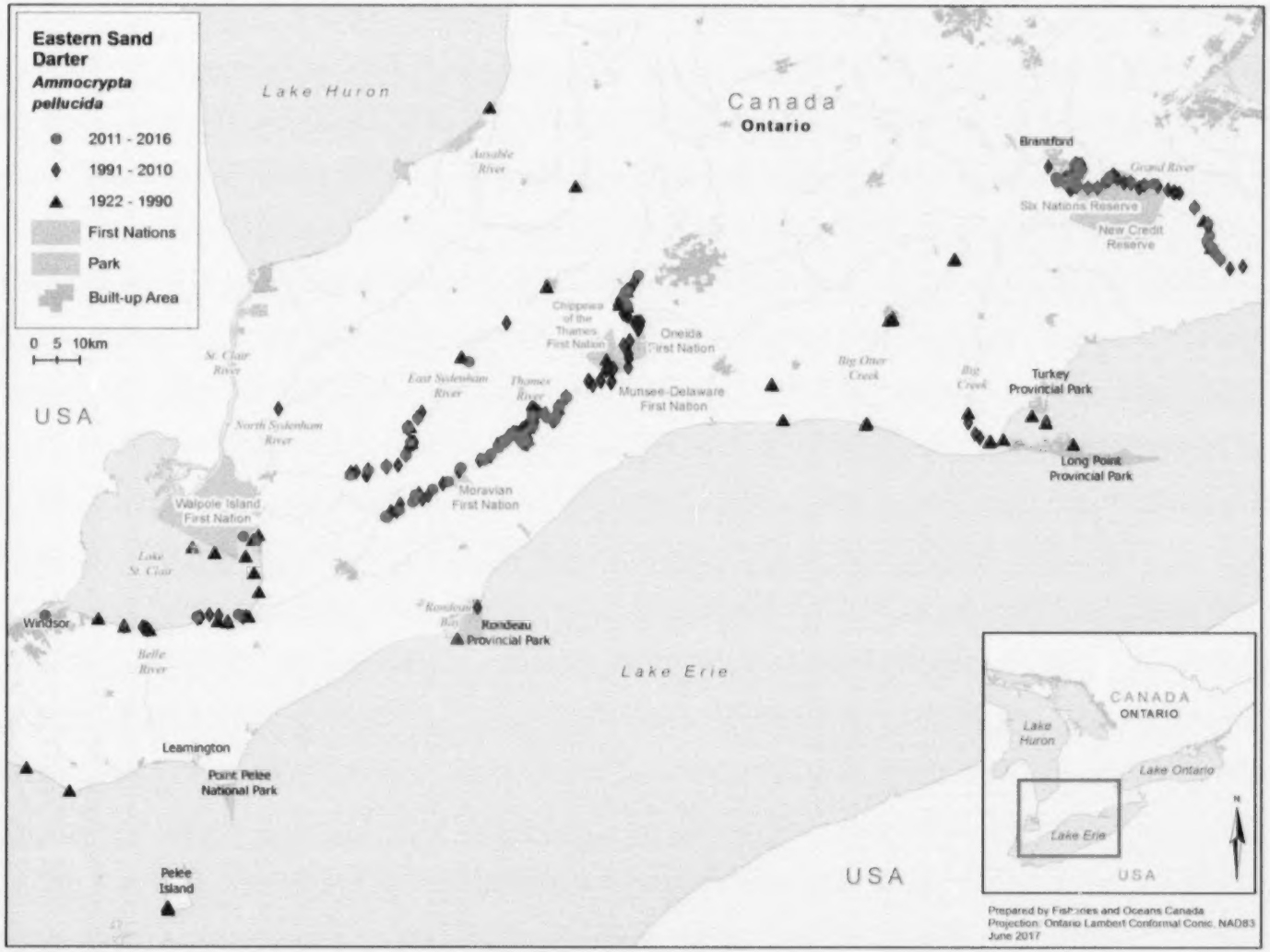


Figure 1. Historical distribution and recent (since 2010) detections of Eastern Sand Darter in southwestern Ontario.

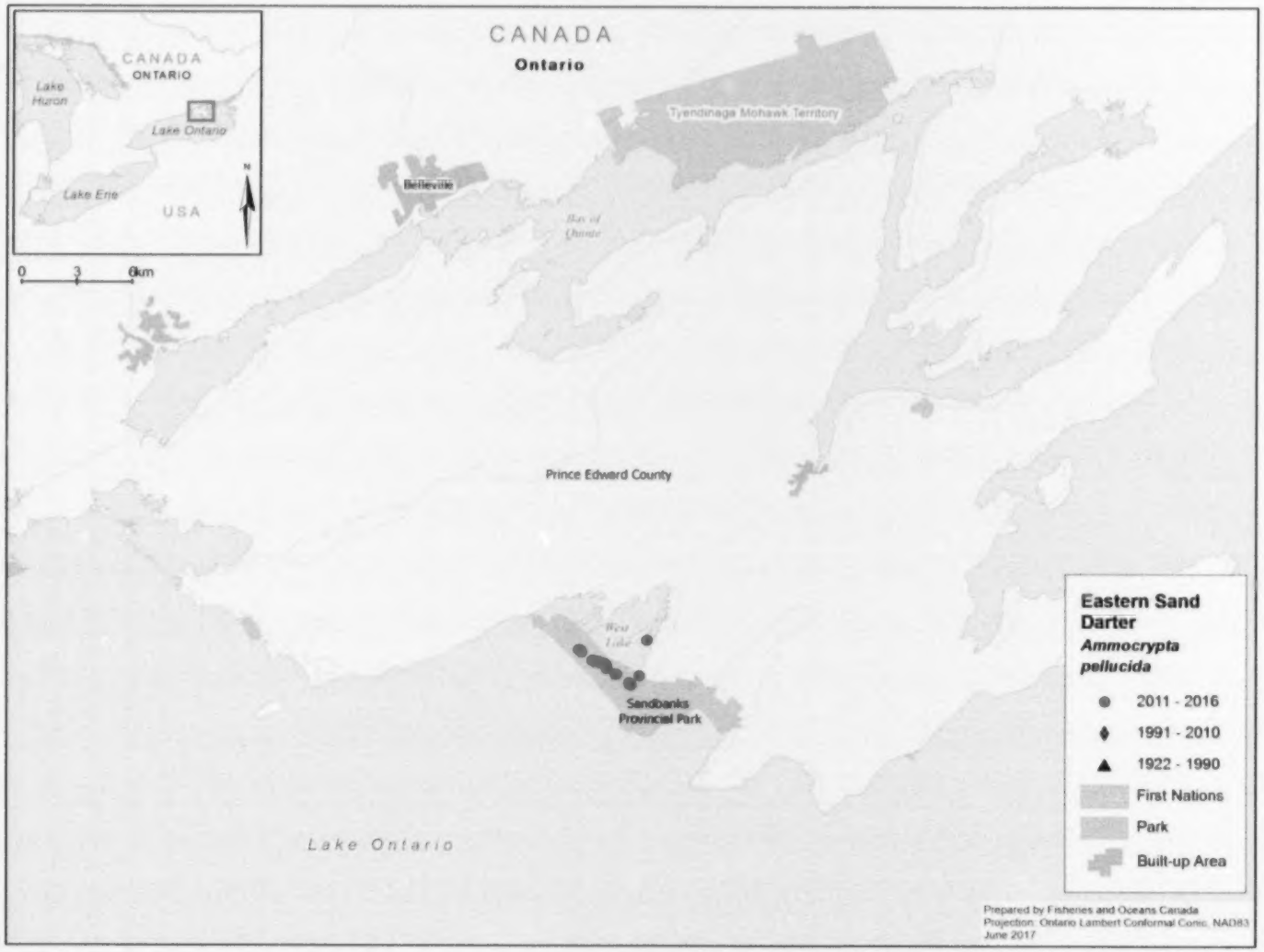


Figure 2. Historical distribution and recent (since 2010) detections of Eastern Sand Darter in eastern Ontario.

2.3 Threats

This section summarizes the threats to survival and recovery of Eastern Sand Darter and threats to its critical habitat, based on the Recovery Strategy.

2.2.1 Threats to Eastern Sand Darter

Table 1, adapted from Bouvier and Mandrak (2010), summarizes the population-level threats to Eastern Sand Darter. Please refer to Section 1.5.2 of the Recovery Strategy for more information on these threats.

Table 1. Threat Status and Certainty for Eastern Sand Darter populations in Ontario. Refer to Bouvier and Mandrak (2010) for details. *Threat Status for all Eastern Sand Darter populations in Canada, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty assigned to each Threat Status, with 1 being reflective of the lowest level of certainty associated with either initial parameter (Threat Likelihood, or Threat Impact). Clear cells do not represent a lack of a relationship between a population and a threat; rather, they indicate that either the Threat Likelihood or Threat Impact was Unknown. Gray cells indicate that the threat is not applicable to the population due to the nature of the aquatic system where the population is located.*

	Lake Huron Drainage	Lake St. Clair Drainage			Lake Erie Drainage						
Threats	Ausable River	Lake St. Clair	Thames River	Sydenham River	Pelee Island	Rondeau Bay	Long Point Bay	Catfish Creek	Big Otter Creek	Big Creek	Grand River
Turbidity and Sediment Loading	High (3)	High (3)	High (3)	High (3)	Medium (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)
Contaminants and Toxic Substances	High (3)	High (3)	High (3)	High (3)	Unknown (3)	High (3)	Medium (3)	Unknown (3)	Unknown (3)	Unknown (3)	Medium (3)
Nutrient Loading	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Low (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)
Barriers to Movement				High (3)					Medium (3)	Low (3)	Medium (3)
Altered Flow Regimes	High (3)		High (3)	High (3)				High (3)	Medium (3)	High (3)	High (3)
Shoreline Modifications	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	High (3)	Low (3)	Medium (3)	TBD	TBD	High (3)
Invasive Species and Disease	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)
Incidental Harvest	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)

2.3.1 Threats to Critical Habitat

Critical habitat for Eastern Sand Darter has been identified, to the extent possible, in Section 2.7 of the Recovery Strategy. Table 2 provides examples of activities that are likely to result in the destruction of critical habitat (i.e., threats to critical habitat). The list of activities provided in this table is neither exhaustive nor exclusive, and their inclusion has been guided by the relevant threats to habitat described in the Recovery Strategy. For more details on the activities likely to result in the destruction of critical habitat, consult the Recovery Strategy.

Table 2. Threats to critical habitat of Eastern Sand Darter, extracted from the Recovery Strategy.

Threat	Activities	Effect-Pathway
Habitat Modifications	• Dredging • Grading • Excavation • Placement of material or structures in water (e.g., groynes, piers, infilling, partial infills, jetties) • Shoreline hardening	Changes in bathymetry and shoreline morphology caused by dredging and nearshore grading and excavation can remove (or cover) preferred substrates, change flow patterns, potentially affecting nutrient levels and water temperatures. Placing material or structures in water reduces habitat availability (e.g., the footprint of the infill or structure is lost). Placing of fill can cover preferred substrates. Changing shoreline morphology can result in altered flow patterns, change sediment depositional areas, reduce oxygenation of substrates, cause erosion, and alter turbidity levels. These changes can promote aquatic plant growth and cause changes to nutrient levels. Hardening of shorelines can reduce organic inputs into the water and alter water temperatures, potentially, affecting the availability of prey for this species.
Habitat Modifications	• Water extraction • Change in timing, duration and frequency of flow	Water extraction can affect surface water levels and flow and groundwater inputs into streams and rivers, affecting habitat availability, the oxygenation of substrates, and

Threat	Activities	Effect-Pathway
		prey abundance. These impacts stemming from water extraction activities can negatively affect Eastern Sand Darter growth, especially during the young-of-the-year (YOY) life stage[2] Altered flow patterns can affect sediment deposition (e.g., changing preferred substrates), oxygenation of substrates, and prey abundance.
Habitat Modifications	• Unfettered livestock access to waterbodies • Grazing of livestock and ploughing to water's edge	Damage to shorelines, banks, and watercourse bottoms from unfettered access by livestock can cause erosion and sedimentation, affecting substrate oxygenation and water temperatures. Such access can also increase organic nutrient inputs into the water, causing nutrient loading and potentially promoting algal blooms, and decreasing prey abundance.
Toxic Compounds	• Over application or misuse of herbicides and pesticides • Release of urban and industrial pollution into habitat	Introduction of toxic compounds into habitat used by this species can change water chemistry affecting habitat availability or use and cause increased aquatic plant growth, affecting spawning and recruitment success.
Nutrient Loadings	• Over-application of fertilizer and improper nutrient management (e.g., organic debris management, wastewater management, animal waste, septic systems and municipal sewage)	Improper nutrient management can cause nutrient loading of nearby waterbodies. Elevated nutrient levels can cause increased aquatic plant growth, changing water temperatures, and slowly change preferred flows and substrates. Oxygen levels in substrates can also be negatively affected.
Siltation and Turbidity	• Altered flow regimes causing erosion and changing sediment transport (e.g., tiling of agricultural drainage systems, removal of riparian zones). • Work in or around water with improper	Improper sediment and erosion control or mitigation can cause increased turbidity levels, changing preferred substrates and their oxygen levels, potentially reducing feeding success or prey availability, impacting the

[2] Further information that was not presented in the Recovery Strategy has been added to this table

Threat	Activities	Effect-Pathway
	sediment and erosion control (e.g., overland runoff from ploughed fields, use of industrial equipment, cleaning or maintenance of bridges or other structures)	growth of aquatic vegetation, and possibly excluding fish from habitat due to physiological impacts of sediment in the water (e.g., gill irritation). Many of these resulting impacts can lead to growth limitations for Eastern Sand Darter populations, especially during the YOY life stageP19TP[1]. Also see: Habitat modifications - change in timing, duration and frequency of flow.
Riparian Vegetation Removal	• Mechanical removal	Removal of riparian vegetation can cause erosion and increase turbidity, ultimately affecting preferred substrates and oxygenation of substrates. Water temperatures can also be negatively affected by removal of riparian vegetation, and water velocities can be increased during high-water events.

2.4 Recovery

This section summarizes the information on the population and distribution objectives that are necessary for the recovery of Eastern Sand Darter, and on performance indicators that provide a way to define and measure progress toward achieving the population and distribution objectives found in the Recovery Strategy.

2.4.1 Recovery Goal and Population and Distribution Objectives

Sections 2.2-2.4 of the Recovery Strategy identified the recovery goal, population and distribution objectives, and short-term recovery objectives necessary for the recovery of the species.

Recovery Goal

The long-term goal (>20 years) is to maintain self-sustaining, extant populations and to restore self-sustaining populations to formerly occupied habitats where feasible.

Population and Distribution Objectives

The population and distribution objective for Eastern Sand Darter is to ensure the survival of self-sustaining population(s) at the six extant locations (Sydenham River, Thames River, Lake St. Clair, Big Creek, Grand River, Lake Erie [Long Point Bay]) and restore self-sustaining population(s) at the following locations: Ausable River, Lake Erie (Rondeau Bay and Pelee Island), Catfish Creek, and Big Otter Creek, where feasible.

Short-term Recovery Objectives (5 - 10 years)

In support of the long-term goal, the following short-term recovery objectives will be addressed over the next 5 -10 years:

i. Refine population and distribution objectives;
ii. Ensure the protection of critical habitat;
iii. Determine long-term population and habitat trends;
iv. Evaluate and minimize threats to the species and its habitat;
v. Investigate the feasibility of population supplementation or repatriation for populations that may be extirpated or reduced;
vi. Enhance efficiency of recovery efforts through coordination with aquatic and terrestrial ecosystem recovery teams and other relevant or complementary groups/initiatives; and,
vii. Improve overall awareness of the Eastern Sand Darter and the role of healthy aquatic ecosystems, and their importance to humans.

2.4.2 Performance Indicators

Table 3. Section 2.6 of the Recovery Strategy includes the following performance indicators to define and measure progress toward achieving recovery objectives[3].

Recovery Objectives	Performance Indicators
i. Refine population and distribution objectives	• Existing populations and historical sites and potential habitats have been sampled • Gained knowledge of currently occupied and potential of historical habitats
ii. Ensure the protection of critical habitat	• Monitoring indicates that populations remain extant at known sites • Implementation of management measures in Table 7 of the recovery strategy • Complete description of Eastern Sand Darter critical habitat
iii. Determine long-term population and habitat trends	• Monitoring program has been developed.
iv. Evaluate and minimize threats to the species and its habitat.	• Monitoring and/or research has been conducted to clarify number, extent and severity of threats to Eastern Sand Darter.
v. Investigate the feasibility of population supplementation or repatriation for populations that may be extirpated or reduced.	• Research has been conducted to evaluate feasibility of translocations, repatriations and captive rearing.
vi. Enhance efficiency of recovery efforts through coordination with aquatic and terrestrial ecosystem recovery teams and other relevant or complementary groups/initiatives	• Outreach program developed and materials distributed.
vii. Improve overall awareness of the Eastern Sand Darter and the role of healthy aquatic ecosystems, and their importance to humans.	• Formalized partnerships developed to increase awareness and formulate action plans towards recovery.

However, some indicators may not be measurable within the time frame covered in this Progress Report. In such cases, the implementation of the recovery approaches and critical

[3] The Recovery Strategy followed an older template that measured performance based on recovery objectives and not population and distribution objectives.

habitat studies will help report on the progress toward achievement of the performance indicators.

3 Progress Towards Recovery

The Recovery Strategy for Eastern Sand Darter divides recovery effort into three broad categories: 1) Research and Monitoring; 2) Management and Habitat Protection; and, 3) Stewardship, Outreach and Education. Within these categories, 17 broad strategies are identified; progress in carrying out these broad strategies is reported in Section 3.1. Section 3.2 reports on the activities identified in the Schedule of Studies to identify critical habitat. Section 3.3 reports on the progress on meeting the performance indicator and other commitments (e.g., action plan and Critical Habitat Order) identified in the Recovery Strategy and information obtained through implementing the Recovery Strategy Activities supporting recovery.

3.1 Activities Supporting Recovery

Tables 4-6 provide information on the implementation of activities undertaken to address the approaches and broad strategies identified in the Recovery Planning Table of the Recovery Strategy.

Table 4. Recovery approaches for Eastern Sand Darter in Ontario – research and monitoring.

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[4]
R1. Habitat requirements	Refine knowledge of seasonal habitat requirements for all life stages especially juvenile.	No research has been conducted in the last five years that characterizes the seasonal habitat requirements of Eastern Sand Darter at various life stages; however, an occupancy modelling study (Dextrase et al. 2014b) has confirmed that substrate size is the most important variable dictating the presence of Eastern Sand Darter, with sand and fine gravel being preferred. Furthermore, water clarity as well as distance upstream of dams were also important variables that explain Eastern Sand Darter occupancy in a given reach.	ii	DFO
R2. Habitat surveys and mapping	Evaluate and map the distribution, quantity and quality of habitat in the vicinity of known populations.	The Canadian Wildlife Service regularly monitors water quality parameters (e.g., turbidity, oxygen levels, and temperature) in coastal wetlands within Lake St. Clair, Lake Erie, and Lake Ontario where Eastern Sand Darter populations can be found. A model of available habitat within Long Point Bay is currently in development that will provide insight regarding threat impacts.	iii	CWS, DFO, UT
R3. Background surveys and monitoring – extant, historical and potential new locations	Develop a long-term monitoring program that includes standardized sampling protocol to monitor for trends over time in distribution and abundance for all life stages. Incorporate findings into a routine population	Targeted sampling was not conducted in these three watersheds; however, non-targeted sampling (Fish/Mussel Overlap Study and Asian Carps Great Lakes Monitoring) was conducted within the Ausable River and Big Otter Creek. No Eastern Sand Darter were detected at either location as a result of these sampling efforts. No DFO sampling, targeted or non-targeted, has been conducted in the Catfish Creek watershed in the last five years. EDNA sampling for Eastern Sand Darter was conducted in the Grand River at 49 sites, one of which was located immediately downstream of the	i, iii	CWS, DFO, UW and McGill U, LPRCA, OMNRF, UT

[4] Acronyms listed in Appendix 1.

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[4]
	monitoring program.	Wilkes Dam (evidence of the species here could indicate its presence upstream of the dam); however, the presence of Eastern Sand Darter was not detected using this method, including in stream reaches where the species is known to occur. Non-target sampling (Round Goby [*Neogobius melanostomus*] Distribution Survey), using a suitable gear type (Missouri trawl), was conducted in 2013 below the Wilkes Dam resulting in the detection of 502 Eastern Sand Darter. In contrast, continued sampling conducted upstream of the Dam in 2014 did not lead to the detection of any Eastern Sand Darter. No targeted sampling for Eastern Sand Darter was conducted in the Thames River. Non-target surveys were conducted throughout the watershed leading to the detection of 473 Eastern Sand Darter. Furthermore, sampling conducted within the Thames River by external agencies led to the capture of 700 Eastern Sand Darter. EDNA sampling targeting Easter Sand Darter was conducted in the Sydenham River (where Eastern Sand Darter is known to occur) in 2013, as a means of validating this sampling technique; however, the presence of Eastern Sand Darter was not detected using this method. Targeted sampling was also conducted in 2013 (Missouri trawl) in the Sydenham River at seven sites in the main branch and five sites in the north branch. No Eastern Sand Darter were captured as a result of these sampling events. In addition, non-target sampling projects were conducted using suitable gear types in the main branch as well as the north and east branches. A total of 14 individuals were		

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[4]
		captured in 2012 in the watershed. While no Eastern Sand Darter were detected in the North Sydenham River, three sites (Fish/Mussel Overlap study) were sampled in Bear Creek, which could represent search effort for the species outside of its known distribution. Furthermore, sampling conducted by external agencies led to the detection 12 Eastern Sand Darter. No targeted sampling has been conducted for Eastern Sand Darter in Lake St. Clair since the publication of the Recovery Strategy; however, three non-target surveys for the Northern Madtom (*Noturus stigmosus*), using a potentially effective gear type, were conducted in 2010, 2012 and 2013 leading to the detection of two Eastern Sand Darter. No targeted sampling was conducted for Eastern Sand Darter in coastal areas of Lake Erie since the Recovery Strategy was drafted; however, a number of non-target surveys have been conducted using a variety of gear types in locations such as Rondeau and Long Point bays, Georgie, Indian, and Willow creeks, Willow Creek Drain, McLean's Drain and Nanticoke Creek (Grand River, as well as Catfish and Big Otter creeks, which were already discussed earlier). None of the aforementioned sampling led to detections of Eastern Sand Darter. No targeted sampling has occurred in Big Creek (Long Point Bay) since 2008. Furthermore, no non-target sampling has occurred in Big Creek since 2012. Although some unquantified sampling has been conducted by Long Point Region Conservation Authority in 2011, this activity has not been implemented.		

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[4]
		Sampling conducted by the OMNRF led to the detection of Eastern Sand Darter in West Lake within the Lake Ontario watershed in 2013. This led to further sampling, conducted collaboratively between DFO and OMNRF for this species within West Lake in 2013-2015, as well as North (North Beach) and Weller's bays, which are also found on the western edge of Prince Edward County (Reid and Parna 2015 unpublished; Reid and Kopf 2016 unpublished). In total, 1284 Eastern Sand Darter were caught (all within West Lake) as a result of this sampling. Investigations regarding the degree of sampling effort, the optimal gear type as well as variables for predicting the occupancy of Eastern Sand Darter have been undertaken in the last five years. Dextrase et al. (2014a) observed that both the back-pack electrofishing and seine netting sampling techniques were generally comparable in their ability to detect Eastern Sand Darter. Detection probabilities varied among watersheds leading to disparities in the sampling effort required. Eastern Sand Darter occupancy was observed to be positively related to smaller substrates including sands and fine gravel, as well as water clarity and velocity (Dextrase et al. 2014a). Furthermore, Dextrase et al. (2014b) also identified the distance upstream of dams as another explanatory variable for Eastern Sand Darter occupancy. Non-target sampling also led to the detection of Eastern Sand Darter within the Detroit River in 2013. Although this species is known to occur within Lake St. Clair, its presence within the Detroit River is a new discovery. Non-target surveys were conducted in Long Point		

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[4]
		National Wildlife Area (NWA) inland ponds by CWS and by UT in the NWA wetlands in 2016 and 2017; Eastern Sand Darter was not detected during these surveys.		
R4. Threat clarification - habitat	Investigate and evaluate the significance of habitat threat factors that may be impacting extant populations. Take steps to mitigate immediate threats identified.	Research has been conducted to determine if specific dredging activities proposed for Lake St. Clair will impact Eastern Sand Darter (Barnucz et al. 2015). Comprehensive sampling, using an appropriate gear type, only led to the detection of one Eastern Sand Darter, suggesting that the species' abundance is extremely low in the area; therefore, the authors conclude that impacts from these projects should be low provided that sufficient mitigation steps are followed. Although threat assessment was not a focus of the study, Dextrase et al. (2014b) modelled Eastern Sand Darter occupancy at varying levels of spatial scale and documented that occupancy was affected by the distance upstream of dams (at the reach level) providing empirical evidence that dams are a threat to this species.	iv	DFO, OMNRF, TU, UT
R5. Threat clarification – invasive species	Investigate the mechanisms of impact of Round Goby on Eastern Sand Darter. Monitor distribution of Round Goby in areas of Eastern Sand Darter populations.	Sampling has been conducted from 2013-2015 that examines the potential distributional overlap between Round Goby and Eastern Sand Darter. Sampling has been conducted in West Lake from 2013-2015 (Lake Ontario watershed), where Eastern Sand Darter was discovered in 2013. Sampling was also conducted in North Bay (North Beach) and Weller's Bay in 2014, both of which are waterbodies found in close proximity to West Lake; however, no Eastern Sand Darter were detected in these areas (Reid and Parna 2015 unpublished; Reid and Kopf 2016 unpublished). The data gathered from these sampling projects will be used to model the impact of Round Goby on the distribution of Eastern Sand Darter within West Lake (Reid and Kopf 2016 unpublished).	iv	DFO, OMNRF, McGill U, UT, ISC

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[4]
		Research is ongoing that investigates potential dietary and niche overlaps between Round Goby and native darter species, including the Eastern Sand Darter, in the Grand, Sydenham, and Thames rivers (D. Raab, McGill University, pers. comm., 2016). An additional project explores the mechanisms through which Round Goby impact Easter Sand Darter in the wake of flow modifications resulting from low-head dams (D. Raab, McGill University, pers. comm., 2016). These authors observed that these two species have inverse preferences regarding water velocity, stream morphology and sediment composition indicating that anthropomorphic alterations to stream flow, such as low-head dams, facilitate an increased abundance of Round Goby and a decrease in Eastern Sand Darter. The future impacts of climate change have been investigated through the development of a model that projects Common Reed (*Phragmites australis*) expansion associated with water level fluctuations.		
R6. Captive rearing and repatriations	Where repatriations are deemed appropriate for restoring populations (historical or degraded), develop a repatriation plan.	While no formal management plan for the repatriation of Eastern Sand Darter to previously occupied habitats has been drafted at this point, research conducted by Ginson et al. (2015) investigating the genetic variation of the Eastern Sand Darter, both among and within watersheds, has led to recommendations in terms of identifying suitable donor populations. For example, supplementation and repatriation plans should seek geographically proximal donor populations, as well as those with contemporary and historical genetic connections. In addition, further research involving occupancy modelling has determined that the Ausable River, Big Otter Creek and Big Creek have a high probability of	v	DFO, UW

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[4]
		supporting supplemented or repatriated Eastern Sand Darter and as such should be considered as candidates for future reintroductions (Dextrase et al. 2014b).		
R7. Conservation genetics	Examine the degree of genetic variation and isolation within (i.e., small populations and inbreeding concerns) and among populations across its North American range.	Ginson et al. (2015) examined the genetic variation of Eastern Sand Darter populations in the Ohio, Wabash, Great Lakes, and St. Lawrence drainages. Within the Great Lakes drainage, genetic variation was compared among the Grand, Sydenham, and Thames rivers. The authors observed a low degree of genetic differentiation between the Thames and Sydenham rivers, while the Grand River was significantly different from the other two. Furthermore, there was a high degree of genetic connectivity among habitat patches within a given watershed, suggesting that: a) inbreeding depression is not likely a major concern; and, b) dams, such as the Wilkes Dam on the Grand River, are not resulting in substantial genetic differentiation.	v	DFO, UW
R8. Habitat modelling	Develop a predictive habitat model to identify potential Eastern Sand Darter sites and significant habitat areas.	Dextrase et al. (2014) identified habitat variables to model occupancy.	ii	OMNRF

Table 5. Recovery approaches for Eastern Sand Darter in Ontario – management and habitat protection.

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[5]
M1. Coordination with other recovery teams and relevant organizations	Work with relevant organizations (e.g., conservation authorities, OMNRF), First Nations, and ecosystem/single species recovery teams to share knowledge, and implement recovery actions.	Collaboration with existing ecosystem recovery teams such as the Essex-Erie Fish Species at Risk and the Ausable river recovery teams to implement recovery measures has been ongoing. Similarly, many of these activities have been implemented jointly with other organizations including the CAs, the OMNRF, the OLTA, as well as a number of academic partners.	vi, vii	OMNRF, ABCA, SCRCA, LTVCA, UTRCA, ERCA, CCCA, LPRCA, GRCA, NPRCA, QRCA, OLTA, UW, UT, UG, TU
M2. Habitat management and policy	Ensure planning and management agencies, including local First Nations, recognize the importance of fluvial and long-shore processes and sources of sand bedload in the maintenance of Eastern Sand Darter habitats. Ensure that flow requirements of the Eastern Sand Darter are considered in the management of water supply and flow regimes.	No progress has been made in this area at this stage; however, earlier research conducted by Drake et al. (2008) has demonstrated that YOY growth is positively correlated with higher mean annual water discharge, most of which is likely attributable to spring pulses. Based on this information, the Grand and Thames rivers may be important watersheds to focus the implementation of the measure on as they both regulate stream flows and limit the degree of spring pulses.	ii, iv	
M3. Assessment of watershed-scale stressors	In cooperation with relevant ecosystem recovery teams and First Nations, address watershed-scale stressors to populations and their habitat.	Recovery objectives have been implemented within watersheds found in Essex region as well as coastal areas of Lake Erie through cooperation with the Essex-Erie Fish Recovery Team.	iv, vi	EERT

[5] Acronyms listed in Appendix 1.

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[5]
M4. Invasive species management plan	Develop a management plan addressing potential risks and proposed actions in response to the arrival or establishment of invasive species.	No such management plan has been developed in the last five years; however, an action plan to address the potential arrival/establishment of high priority aquatic invasive species (AIS) will be developed by the DFO's AIS Program. The focus of this program is to prevent the introduction of AIS, respond rapidly to the detection of new species, and manage the spread of already established AIS (e.g., Round Goby).	iv, vi	
M5. Municipal planning	Encourage municipalities and First Nations to include the concerns about Eastern Sand Darter habitat conservation in the municipal planning documents.	DFO species at risk guidance has been provided to Ontario municipalities that have aquatic (fish/mussel) species at risk within their areas to be used for municipal Official Plan updates. Initial contact has been made with 30 priority municipalities that were actively updating their official plans. Species at risk guidance was updated in 2015 and additional contact/outreach to these and all other Ontario municipalities with species at risk in their areas is proposed for 2016-17.	vi, vii	DFO

Table 6. Recovery approaches for Eastern Sand Darter in Ontario – stewardship.

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[6]
S1. Stewardship - awareness	Encourage and strengthen stewardship efforts with managers, stakeholders, First Nations and citizens aimed at protecting Eastern Sand Darter habitats.	A total of 1169 individuals received stewardship training from CA staff through outreach programs that received funding from DFO.	vii	ABCA, SCRCA, LTVCA, GRCA
S2. Stewardship – implementation of BMP's	Work with landowners and First Nations to implement BMPs in areas that will provide the most benefit. Encourage the completion and implementation of Environmental Farm Plans and Nutrient Management Plans	Restoration and BMP initiatives including vegetation planting (532 ha), vegetation and invasive species removal (terrestrial species such as Common Reed [*Phragmites australis australis*]) (44 ha), riparian restoration (69 ha) as well as other habitat activities (449 ha) have been implemented by CAs, with HSP funding from DFO, in eight watersheds, and/or municipalities where Eastern Sand Darter occurs at 238 sites. Habitat improvement projects funded through the SARSF from the OMNRF were conducted in the Ausable, Sydenham, and Thames rivers.	ii, iv	DFO, ABCA, SCRCA, UTRCA, ERCA, OMNRF, CCCA, LPRCA, GRCA,
S3. Communication plan	Develop a communication and awareness-raising plan that identifies partners and target audiences. Raise the awareness and develop information products, educational and outreach opportunities, stewardship resources and specific BMP's that will assist with the recovery of	No communication plan has been developed at this time and likely will not be developed in the future. Currently, species at risk information is communicated to the public through DFO's outreach program as well HSP funding for external outreach projects.	v, vi	

[6] Acronyms listed in Appendix 1.

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[6]
	Eastern Sand Darter.			
S4. Coordination with other groups	Collaborate with relevant groups, including First Nations groups and recovery teams to address recovery actions to benefit Eastern Sand Darter	Collaboration with existing ecosystem recovery teams such as the Essex-Erie Fish Species at Risk and the Ausable River recovery teams to implement recovery measures has been ongoing. Similarly, many of these activities have been implemented jointly with other organizations including the CAs, the OMNRF, the OLTA, as well as a number of academic partners.	v, vi	OMNRF, ABCA, SCRCA, LTVCA, UTRCA, ERCA, CCCA, LPRCA, GRCA, NPRCA, QRCA, OLTA, UW, UT, UG, TU
S5. Invasive species - awareness	Increase public awareness of the impacts of invasive species on the natural ecosystem, encourage the use of the Ontario invasive species reporting system.	AIS information has been disseminated through: the Watercraft Inspection Program; educational outreach material distributed by DFO (public postings and direct engagement); and, the distribution of info cards (e.g., ABCA's Old Ausable Channel Fish Community card provides info regarding species at risk as well as invasive species that threaten them). Furthermore, licensed commercial baitfish harvesters in Ontario have completed Hazard Analysis and Critical Control Point training, which focuses on impacts and prevention of the spread of AIS. In addition, research funded by DFO (Drake and Mandrak 2014a; 2014b) has quantified the risk of invasive species introductions throughout the province. Guidelines and effective strategies for the control and removal of Common Reed are described for invasive species mitigation and wetland restoration	v, vi	ABCA, DFO, OFAH, OMNRF

Broad Strategy	Approach	Description and Results	Recovery Objectives Addressed	Participants[6]
		projects (OMNRF 2011). The OMNRF, in partnership with OFAH, has developed the Early Detection Distribution Mapping System that allows the general public and citizen scientists to share their information regarding the distribution of Common Reed and provides guidance and direction on how to control this invasive species.		
S6. Stewardship- financial assistance/incentives	Facilitate access to funding sources for landowner and local community groups engaged in stewardship activities.	HSP funding is provided by DFO and SARSF funding is provided by the OMNRF to support local stewardship initiatives led primarily by environmental non-government organizations. The activities supported facilitate the implementation of recovery efforts, BMPs associated with water quality improvements, sediment load and reduction, etc. (e.g., HSP funding has led to a number of habitat improvements in Eastern Sand Darter habitat such as Rondeau Bay). Further stewardship related funding is available from organizations such as the OFA (Species at Risk Farm Incentive Program).	ii	DFO, OMNRF, OFA

3.2 Activities Supporting the Identification of Critical Habitat

Table 7 provides information on the implementation of the studies outlined in the Schedule of Studies to Identify Critical Habitat in the Recovery Strategy. Each study has been assigned one of four statuses:

1) *Completed:* the study has been carried out and concluded
2) *In progress:* the planned activity is underway and has not concluded
3) *Not started*: the activity has been planned but has yet to start
4) *Cancelled*: the planned activity will not be started or completed

Study	Timeline	Status	Descriptions and Results	Participants[7]
Conduct studies to determine the habitat requirements for all life stages.	2011-2014	In Progress	DFO initiated an intensive research project in 2017 to better understand the reproductive ecology and early life history of riverine species at risk, including Eastern Sand Darter. The goal of the project was to quantify the relationship between environmental factors (cumulative thermal energy and in-stream flows) and the timing of gonad development, spawning, hatching, and the emergence and drift of larvae. The study will refine the critical habitat of adults, eggs, and larvae, and will also help to better understand the relationship between environmental factors and year-class strength for the species. The research was accomplished through larval drift sampling, supplemented with continuous measurements of in-stream flows and temperature (A. Drake, DFO, pers. comm., 2017).	DFO
Survey and map habitat quality and quantity within historical and current sites, as well as sites adjacent to currently occupied habitat.	2011-2014	Not started	No information available	

[7] Acronyms listed in Appendix 1

Study	Timeline	Status	Descriptions and Results	Participants'
Conduct additional species surveys to fill in distribution gaps, and to aid in determining population connectivity.	2011-2014	In progress	No targeted sampling has been conducted by DFO in the last five years to address this measure. However, Reid and Dextrase (2014) detected Eastern Sand Darter in West Lake (Lake Ontario watershed) in 2013, which represents a major extension to the known distribution of the species.	OMNRF
Create a population-habitat supply model for each life stage.	2014-2016	In progress	No progress has been made in this area that is focused specifically on the Eastern Sand Darter; however, a literature review is underway that examines the relationship between habitat supply and mortality for all Canadian freshwater fishes that will inform this objective either directly through review of Eastern Sand Darter related literature, or indirectly, through review of literature concerning similar darter species (A. Drake, pers. comm., 2016).	DFO
Based on information gathered, review population and distribution goals. Determine amount and configuration of critical habitat required to achieve goal if adequate information exists. Validate model.	2014-2016	In progress	Same as above.	DFO

3.3 Summary of Progress Towards Recovery

3.3.1 Status of Performance Indicators

Table 8 provides a summary of the progress made toward meeting the performance indicators outlined in Table 4. Each indicator has been assigned one of four statuses:

1) *Not met:* The performance indicator has not been met, and little to no progress has been made
2) *Not met, underway:* The performance indicator has not been met, but there has been moderate to significant progress made
3) *Met:* The performance indicator has been met and no further action is required
4) *Met, ongoing:* The performance indicator has been met, but efforts will continue until such time the population is considered to be recovered (i.e., the indicator will be reported against in the next five-year progress report)

Performance Indicator	Status	Details	Next Steps
Monitoring indicates that populations remain extant at known sites. Implementation of management measures in Table 7 of the Eastern Sand Darter Recovery Strategy.	Not met, underway	Targeted sampling has been undertaken in the Sydenham River to determine the extent and status of the population therein. Non-targeted surveys have been conducted within the Ausable and Thames rivers, Big Otter and Big creeks, as well as Lake St. Clair and coastal habitats/tributaries of Lake Erie. Some of these surveys led to species detections; however, the nature of these sampling surveys (locations, gear types etc.) may limit their utility to address this measure.	Targeted sampling should be conducted within the Ausable and Thames rivers, Big Otter and Big creeks, as well as Lake St. Clair and coastal habitats/tributaries of Lake Erie.
Existing populations and historical sites and potential habitats have been sampled.	Not met, underway	Same as above – historical sites would include areas of the Sydenham River, Big Otter and Big creeks, as well as coastal habitats/tributaries of Lake Erie.	Conduct targeted sampling in identified locations.
Gained knowledge of currently occupied and potential of historical habitats.	Not met, underway	Eastern Sand Darter was detected as a result of non-target surveys within the Grand, Sydenham, and Thames rivers as well as Lake St. Clair. This information provides presence absence and/or abundance information for Eastern Sand Darter populations within extant locations. Furthermore, an occupancy modelling study (Dextrase et al. 2014b) has	Conduct targeted sampling in identified locations.

Performance Indicator	Status	Details	Next Steps
		characterized habitat associations of Eastern Sand Darter within the Grand and Thames rivers. Research involving occupancy modelling has determined that the Ausable River, Big Otter Creek and Big Creek have a high probability of supporting supplemented or repatriated Eastern Sand Darter and as such should be considered as candidates for future reintroductions (Dextrase et al. 2014b).	
Complete description of Eastern Sand Darter critical habitat.	Not met, underway	The occupancy modelling study (Dextrase et al. 2014b) can be considered progress in this direction.	Conduct further research to refine knowledge of seasonal habitat requirements for all life stages (especially juvenile).
Monitoring program has been developed.	Not met, underway	A long-term sampling protocol has not been fully developed at this time; however, progress has been made in terms of investigations into the optimal gear type, sampling effort required, detection probabilities and variables for predicting the occupancy of Eastern Sand Darter (Dextrase et al. 2014a).	Apply the findings of this research to generate a monitoring program that involves use of the optimal gear (electrofishing or seine netting) applied at locations that are likely to be occupied by the Eastern Sand Darter.
Research has been conducted to clarify number, extent and severity of threats to Eastern Sand Darter.	Not met, underway	Research is underway that investigates competitive interactions between Round Goby and native darters including Eastern Sand Darter. These projects involve investigations into dietary overlap and competition between Round Goby and Eastern Sand Darter (or a surrogate darter species [i.e., Johnny Darter (*Etheostoma nigrum*]). Furthermore, competitive interactions between Round Goby and Eastern Sand Darter are examined in stream reaches where stream flow has or has not been impacted by low-head dams.	Conduct further research to clarify number, extent and severity of threats to Eastern Sand Darter.
Research has been conducted to evaluate feasibility of translocations, repatriations and captive	Not met, underway	Research conducted by Ginson et al. (2015) investigating the genetic variation of the Eastern Sand Darter, both among and within watersheds, has led to recommendations in terms of identifying suitable donor populations.	Research should be conducted to the feasibility of translocation including the rearing aspect of such a project.

Performance Indicator	Status	Details	Next Steps
rearing.		For example, supplementation and repatriation plans should seek geographically proximal donor populations, as well as those with contemporary and historical genetic connections.	
Outreach program developed and materials distributed.	Met, ongoing	Stewardship training has been provided to a number of individuals by CAs through DFO funding. Similarly, AIS information has been disseminated to the public.	Continue to conduct outreach and provide funding for external outreach activities.
Formalized partnerships developed to increase awareness and formulate action plans towards recovery.	Ongoing	Watershed-based stewardship initiatives funded through HSP and led by Conservation Authority partners (e.g., Ausable Bayfield Conservation Authority, St. Clair Region Conservation Authority) include outreach and education activities that address several species at risk, including the Eastern Sand Darter.	Continue to work with conservation authority partners to implement stewardship initiatives for species at risk, including Eastern Sand Darter.

3.3.2 Completion of Action Plan

The *Action Plan for the Sydenham River in Canada: An Ecosystem Approach* (DFO 2017) was posted as Proposed on the Species at Risk Public Registry on August 25, 2016. Although an ecosystem/multispecies document, this Action Plan includes several components that encompass recovery objectives for Eastern Sand Darter. Additionally, an Action Plan for the Ausable River, which includes Eastern Sand Darter, has been drafted and is expected to be posted on the Public Registry in 2018.

3.3.3 Critical Habitat Identification and Protection

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For Eastern Sand Darter, critical habitat was identified in the Recovery Strategy in the Sydenham and Thames rivers. Critical habitat identified in the Long Point NWA was legally protected by a Description in 2016. In 2017, a Critical Habitat Order made under subsections 58(4) and (5) of SARA was published in the *Canada Gazette* Part 2. The Description and Order are intended to satisfy the obligation to legally protect critical habitat by triggering the prohibition in subsection 58(1) of SARA against the destruction of any part of the species' critical habitat. Since the publication of the Recovery Strategy, research has been conducted that has potentially refined the functions, features, and attributes of critical habitat by confirming the importance of substrate size (preference for sand and fine gravels) and by documenting an association with water clarity as well as stream reaches with limited cover. These findings should be considered during the species' next assessment and incorporated into the functions, features, and attributes table of future recovery strategies, amendments to existing strategies and or action plans for this species.

3.3.4 Recovery Feasibility

Information available at this time suggests that the feasibility of recovery for Eastern Sand Darter has not changed since the publication of the Recovery Strategy.

4 Concluding Statement

Since the publication of the Recovery Strategy in 2012, two major detections of Eastern Sand Darter have been made that significantly refine future population and distribution objectives for this species. For the first time, Eastern Sand Darter has been detected in the Detroit River (Figure 1), which indicates there is likely connectivity between Lake St. Clair and Lake Erie populations. Furthermore, sampling conducted within West Lake, Prince Edward County by the Ontario Ministry of Natural Resources and Forestry (OMNRF) has led to the first detection of Eastern Sand Darter within the Lake Ontario watershed (Figure 2). Ultimately, the detection of Eastern Sand Darter within West Lake gives indication that its distribution is more widespread within Ontario than previously understood; therefore, further sampling should be undertaken to detect other potentially undiscovered populations within the Lake Ontario basin and the Upper St. Lawrence River.

In general, targeted sampling surveys for Eastern Sand Darter have been limited. Only one targeted survey, representing one location (Sydenham River), has been completed to determine whether species numbers have increased or continue to decline. The relative abundance index in the Eastern Sand Darter Recovery Strategy consists primarily of expert opinion, with only one

population on the Thames River having quantitative estimates of relative abundance and population trajectory. For this reason, targeted sampling is required to generate robust quantitative estimates of Eastern Sand Darter population sizes in order to set meaningful population and distribution objectives. Furthermore, monitoring is also needed within the Lake Ontario watershed to detect new populations, as well as within historical locations (e.g., Big Otter Creek) and new locations (e.g., Nanticoke Creek) in coastal areas and tributaries of Lake Erie.

There is currently not enough information available to determine if the conditions within habitats occupied by Eastern Sand Darter have changed since the publication of the Recovery Strategy. As with the aforementioned relative abundance index, the threat status information in the Eastern Sand Darter Recovery Strategy is based solely off of expert opinion and not quantitative analysis. Research objectives centred on threat assessment and mitigation have not been implemented in the last five years; therefore, it is imperative that this form of research should become a focus of future recovery efforts.

Information pertaining specifically to Eastern Sand Darter, as well as more general information that applies to this species through threat information and recommendations for Best Management Practices (BMPs), have been presented or distributed to the general public through Habitat Stewardship Program (HSP) funding. Specifically, 46 000 people have been reached through media broadcasts, 209 801 media items have been printed and 1169 individuals have received stewardship training. Similarly, a number of habitat improvement activities have been conducted throughout areas of the current and historical range of the Eastern Sand Darter. In total, 523 ha of vegetation planting (terrestrial species within riparian zones and catchment areas) has occurred, 44 ha of invasive vegetation has been removed, 69 ha of riparian zone has been restored, along with a number of other general habitat improvement activities.

Overall, progress has been made in terms of stewardship and outreach activities that benefit the Eastern Sand Darter; however, there are still a number of areas where further information is required to fulfill measure prescribed in the Recovery Strategy. Further recovery implementation for the Eastern Sand Darter should focus on pending survey and monitoring, and research measure to fill knowledge gaps.

5 References

Barnucz, J., N.E. Mandrak, L.D. Bouvier, R. Gaspardy, and D.A. Price. 2015. Impacts of dredging on fish species at risk in Lake St. Clair, Ontario. Canadian Science Advisory Secretariat Research Document: 2015/018.

COSEWIC. 2009. COSEWIC assessment and status report on the Eastern Sand Darter *Ammocrypta pellucida*, Ontario populations and Quebec populations, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 49 pp.

Dextrase, A.J., N.E. Mandrak, J. Barnucz, L.D. Bouvier, R. Gaspardy, and S.M. Reid. 2014a. Sampling effort required to detect fishes at risk in Ontario. Canadian Manuscript Report of Fisheries and Aquatic Sciences 3024.

Dextrase, A.J., N.E. Mandrak, and J.A. Schaefer. 2014b. Modelling occupancy of an imperilled stream fish at multiple scales while accounting for imperfect detection: implications for conservation. Freshwater Biology 59: 1799-1815.

DFO. 2011. Recovery Potential Assessment of Eastern Sand Darter (*Ammocrypta pellucida*) in Canada. DFO Canadian Science Advisory Secretariat Science Advisory Report 2011/020.

DFO. 2012. Recovery strategy for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada: Ontario populations. *Species at Risk Act* Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa. vii + 56 pp.

Drake, D.A.R., M. Power, M.A. Koops, S.E. Doka, and N.E. Mandrak. 2008. Environmental factors affecting growth of Eastern Sand Darter (*Ammocrypta pellucida*). Canadian Journal of Zoology 86: 714-722.

Drake, D.A.R. and N.E. Mandrak. 2014(a). Bycatch, bait, anglers, and roads: quantifying vector activity and propagule introduction risk across lake ecosystems. The Ecological Society of America 24: 877-894.

Drake, D.A.R. and N.E. Mandrak. 2014(b). Ecological risk of live bait fisheries: a new angle on selective fishing. American Fisheries Society 39: 201-211.

Finch, M., J.E. Faber, M.A. Koops, S.E. Doka, and M. Power. 2013. Biological traits of Eastern Sand Darter (*Ammocrypta pellucida*) in the Lower Thames River, Canada, with comparisons to a more southern population. Ecology of Freshwater Fish 2: 234-245.

Ginson, R., R.P. Walter, N.E. Mandrak, C.L. Beneteau, and D.D. Heath. 2015. Hierarchal analysis of genetic structure in the habitat-specialist Eastern Sand Darter (*Ammocrypta pellucida*). Ecology and Evolution 5: 695-708.

Reid, S. and A. Dextrase. 2014. First record of *Ammocrypta pellucida* (Agassiz, 1863) (Actinopterygii: Perciformes) from the Lake Ontario Drainage Basin. Check List 10: 1201-1203.

Reid, S. and M. Parna. 2015. 2013-2014 Eastern Sand Darter research report. Aquatic Research Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Peterborough Ontario. March 2015 (Unpublished).

Reid, S. and V. Kopf. 2016. Report on 2015 fish sampling activities for *Species at Risk Act* permit. Ontario Ministry of Natural Resources (Unpublished).

Appendix 1. Acronyms

ABCA	Ausable Bayfield Conservation Authority
BMP	Best Management Practices
CCCA	Catfish Creek Conservation Authority
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
DFO	Fisheries and Oceans Canada
EERT	Essex-Erie Recovery Team
ERCA	Essex Region Conservation Authority
GRCA	Grand River Conservation Authority
HSP	Habitat Stewardship Program
ISC	Invasive Species Centre
LPRCA	Long Point Region Conservation Authority
LTVCA	Lower Thames Valley Conservation Area
NPRCA	Niagara Region Conservation Authority
OFA	Ontario Federation of Agriculture
OFAH	Ontario Federation of Anglers and Hunters
OFNEDA	Ontario First Nations Economic Development Association
OLTA	Ontario Land Trust Alliance
OMAFRA	Ontario Ministry of Food, Agriculture and Rural Affairs
OMNRF	Ontario Ministry of Natural Resources and Forestry
OU	Ohio University
QRCA	Quinte Region Conservation Authority
SARSF	Species at Risk Stewardship Fund
SCRCA	St. Clair Region Conservation Authority
TU	Trent University
UTRCA	Upper Thames River Conservation Authority
UG	University of Guelph
UT	University of Toronto
UW	University of Windsor